

# Heat expansion of star-like cosmic objects induced by the cosmological expansion\*

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## Abstract

The heat expansion of a star-like cosmic object, induced by the cosmological bremsheat production within a moving body, that was predicted by the Projective Unified Field Theory of the author, is approximately treated. The difference to planet-like bodies investigated previously arises from another material constitution. The exponential-like expansion law is applied to a model with numerical values of the Sun. The results are not in contradiction to empirical facts.

## 1 Review

These days it is generally recognized in science that, as the Sun burns through its hydrogen on the main sequence, it steadily grows hotter and therefore more luminous. It is also accepted that through this fact the Sun continuously grows larger. Recently an interesting paper on this subject has been published (Korycansky et al. 2001).

This paper devoted to a similar subject follows the theoretical line of our previous publication on the bremsheat expansion of a moving spherical planet-like body, induced by the expansion of the cosmos (Schmutzer 2000a). This hypothetical bremsheat effect has been derived from the Projective Unified Field Theory (PUFT) of the author (Schmutzer 1995). The moving star-like body considered here may be orbiting around a galactic central body. As usual in astrophysics, the Gauss system of units is used. Let us first repeat the general theoretical results.

The radial expansion velocity of the surface of the sphere ( $r$  radius of the sphere) reads

$$v = \frac{dr}{dt} = 4E_S r \sigma^3 \frac{d\sigma}{dt}. \quad (1)$$

The quantities occurring mean (in our specific terminology):  $\sigma$  is the scalaric world function determined by the scalaric cosmological field equation, whereas

$$E_S = \frac{\Sigma_S}{4} \left( \frac{\gamma_N M_c}{\sigma F_0} \right)^2 \quad (2)$$

is the scalaric cosmic expansion factor with following meaning of the symbols appearing:  $\gamma_N = 6.68 \cdot 10^{-8} \text{ g}^{-1} \text{ cm}^3 \text{ s}^{-2}$  is the Newtonian gravitational constant and  $M_c$  the mass of the central body. In this context one should take account that the

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\*Dedicated to Prof. Dr. R. Kippenhahn on the occasion of his 75th birthday

relation  $M_c = \mathcal{M}_c \sigma$  holds, where  $\mathcal{M}_c$  is the scalmass (invariant constant mass) of the central body. Further

$$\Sigma_S = \frac{f_S \alpha_c}{3c_Q} \quad (3)$$

is the scalaric material factor ( $\alpha_c$  cubic thermal coefficient of dilation,  $c_Q$  specific heat,  $f_S$  heat consumption factor being an individual quantity of the order of magnitude 1), and  $F_0 = \sigma |\mathbf{R} \times \mathbf{V}|$  is the modified arial velocity of the orbiting body (constant of integration) appearing in its angular momentum ( $\mathbf{V}$  orbital velocity,  $|\mathbf{R}|$  distance between the moving body and the galactic central body).

For further mathematical treatment of the equation (1) we assume constancy of the scalaric cosmic expansion factor (2). Then we are able to integrate with the result

$$r = r_b \exp[E_S(\sigma^4 - \sigma_b^4)], \quad (4)$$

where

$$\text{a) } r_b = r(t = t_b) \quad \text{and} \quad \text{b) } \sigma_b = \sigma(t = t_b) \quad (5)$$

mean the value of the radius of the sphere and the value of the scalaric world function at the time of the birth of the cosmic object considered (index  $b$  refers to birth).

## 2 Application of the theory to a star-like cosmic object (Sun as model)

For rough application of the theory presented above we refer to approximate numerical values of the Sun as a numerical model (further short: sun) orbiting around the center of the Galaxy (index  $p$  refers to present, year = y):

$$\begin{aligned} \text{a) } R &= 2.6 \cdot 10^{22} \text{ cm} && (\text{radius of the orbit}), \\ \text{b) } V &= 2.2 \cdot 10^7 \text{ cm s}^{-1} && (\text{orbital velocity of the sun}), \\ \text{c) } M_c &= 1.8 \cdot 10^{44} \text{ g} && (\text{acting mass of the Galaxy}), \\ \text{d) } r_p &= 6.96 \cdot 10^{10} \text{ cm} && (\text{present radius of the sun}), \\ \text{e) } t_{sun} &= 4.66 \cdot 10^9 \text{ y} && (\text{age of the sun}). \end{aligned} \quad (6)$$

Let us mention that the value of the central mass acting at the place of the sun resulted from our theory of the rotation curve (Schmutzer 2001). Obviously this value is different from the usually accepted value of the mass of the whole Galaxy which is somewhat greater.

Apart from these individual values (6) we further need the present cosmological values

$$\begin{aligned} \text{a) } \sigma_p &= 65.19, \\ \text{b) } \left( \frac{d\sigma}{dt} \right)_p &= 1.14 \cdot 10^{-9} \text{ y}^{-1}. \end{aligned} \quad (7)$$

These values result from the solution of the system of the cosmological differential equations of the closed isotropic homogeneous cosmological model investigated in detail (Schmutzer 2000b).

By means of (6a,b) and (7a) we find the value  $F_0 = 3.73 \cdot 10^{31} \text{ cm}^2 \text{ s}^{-1}$ .

The main problem arising now is to find a way to get information on the scalaric expansion factor  $E_S$  of the sun (2). For comparing it is appropriate to remember the results obtained for planet-like cosmic bodies (Schmutzer 2000). We used the following values applied in geophysics for the earth:

$$\begin{aligned} \text{a) } \alpha_c &= 6.84 \cdot 10^{-5} \text{ K}^{-1}, \\ \text{b) } c_Q &= 1.5 \cdot 10^7 \text{ cm}^2 \text{ s}^{-2} \text{ K}^{-1}. \end{aligned} \quad (8)$$

For  $f_S = 0.5$  we obtained the values

$$\begin{aligned} \text{a) } \Sigma_S &= 7.6 \cdot 10^{-13} \text{ cm}^{-2} \text{ s}^2, \\ \text{b) } E_S &= 9.35 \cdot 10^{-8}. \end{aligned} \quad (9)$$

The situation with respect to the sun is insofar qualitatively different from the situation just mentioned, since the interior of the sun consists of gas (mainly H, partly atomic burning to He) with a very high temperature.

For simplicity we approximately treat this problem by referring to an perfect gas for which the relation

$$\bar{\varepsilon} = \frac{m_0}{2} \overline{u^2} = \frac{3kT}{2} \quad (10)$$

is valid ( $m_0$  mass of a gas particle,  $u$  velocity of the gas particles subjected to averaging,  $k$  Boltzmann constant,  $T$  kinetic temperature). As it is well known, for a perfect gas the formulas

$$\begin{aligned} \text{a) } \alpha_c &= \frac{1}{T} = \frac{3k}{m_0 \overline{u^2}}, \\ \text{b) } c_Q &= \frac{3k}{2m_0} \end{aligned} \quad (11)$$

hold. Hence the relations (3) and (2) take the form

$$\Sigma_S = \frac{2f_S m_0}{3kT} \quad (12)$$

and

$$E_S = \frac{f_S m_0}{6kT} \left( \frac{\gamma_N M_c}{\sigma F_0} \right)^2. \quad (13)$$

Using the numerical values (6) and (7) for the sun, we find

$$\left( \frac{\gamma_N M_c}{\sigma F_0} \right)^2 = 2.45 \cdot 10^7 \text{ cm}^2 \text{ s}^{-2}. \quad (14)$$

As mentioned above, it is our aim to treat cosmic bodies globally. Therefore it seems to be acceptable to take the value  $T = 5 \cdot 10^6 \text{ K}$  as an appropriate mean value of the kinetic temperature of the sun. Let us further remember the value of the Boltzmann constant  $k = 1.38 \cdot 10^{-16} \text{ g cm}^2 \text{ s}^{-2} \text{ K}^{-1}$  and the value of the proton mass  $m_p = 1.68 \cdot 10^{-24} \text{ g}$  (being used as the mass of the H-atom constituent of the gas considered). Hence we obtain from (13) the numerical result ( $f_S = 1$ )

$$E_S = 9.92 \cdot 10^{-9}. \quad (15)$$

### 3 Numerical evaluation and plotting for the Sun (as a model)

#### 3.1 Numerical formulas for radius and expansion velocity

Inserting the values (15), (6d) and (7) into formula (1), we find for the present expansion velocity of the surface of the sun

$$v_p = 0.87 \text{ cm y}^{-1}. \quad (16)$$

Further we get information from formula (4) on the temporal behavior of the radius of the sun. Inserting (16) into this equation we arrive at

$$r_p = r_b \exp[9.92 \cdot 10^{-9}(\sigma_p^4 - \sigma_b^4)]. \quad (17)$$

Now from (6d) we know the quantity  $r_p$  and from (7a) the quantity  $\sigma_p$ . As mentioned above, there is a good consensus among astrophysicists that the age of the sun is about 4.66 billion years. Therefore we need the value of  $\sigma$  at the time of birth of the sun. In order to find this value a small excursus to the results of our cosmological model quoted above is necessary.

We arrived at an age of this cosmos of  $18 \cdot 10^9 \text{ y}$ , i.e. we need the cosmological values at the time  $t_b = 13.34 \cdot 10^9 \text{ y}$ . Checking our list of numerical data for the whole cosmos after the big start (Urstart), we find the values  $\sigma_b = \sigma(t = t_b) = 55.44$  and  $\sigma_b^4 = 9.45 \cdot 10^6$ .

Now we are prepared to calculate the radius of the sun at the birth with the result

$$r_b = 6.39 \cdot 10^{10} \text{ cm}. \quad (18)$$

#### 3.2 Plotting of the temporal course of the radius and the velocity

The abscissa of the figures presented in the following refers to the rescaled time  $\eta = 0.945 \cdot 10^{-9} t \text{ y}^{-1}$ . This practically means that the unit  $\Delta\eta = 1$  roughly corresponds to  $10^9 \text{ y}$ . Referring to the figures of the radius, the unit of the radius at the ordinate is given in cm; referring to the figures of the velocity, the unit of the velocity at the ordinate is cm/y.

The temporal course of the radius of the spherical body is presented in Fig. 1 for the whole time scale since the big start.

The temporal course of the radial velocity of the surface of the spherical body is presented in Fig. 2 which shows the course of the velocity for the whole time scale since the big start.

#### 3.3 Annotation to the mass of the Galaxy

In investigating the orbital motion of the sun around the central body of the Galaxy, for physical reasons it is necessary to use the gravitational force just at the place of the moving sun. Because of the matter (particularly dark matter) outside the sun it is obvious that the mass causing the gravitational force mentioned is not the total mass of the Galaxy. We recently treated the problem of the radial mass distribution in the Galaxy within the framework of our theory of the rotation curve of stars (Schmutzer 2001). In that paper we came to the numerical value (6c) of the gravitationally acting mass at the place of the sun. All numerical calculations performed above are based on this value.

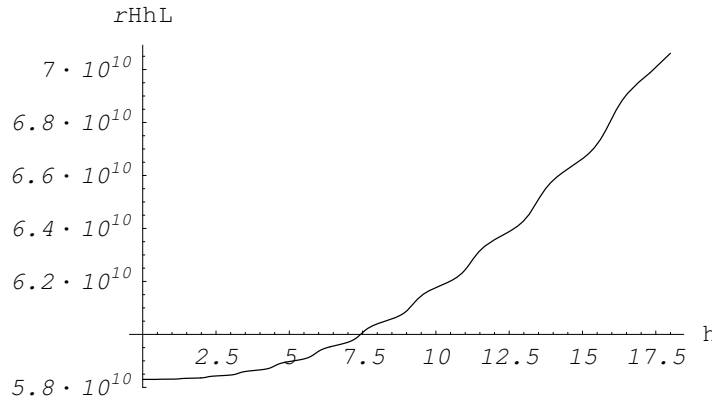


Figure 1: Temporal course of the radius for the whole time scale from the big start to  $18 \cdot 10^9$  y

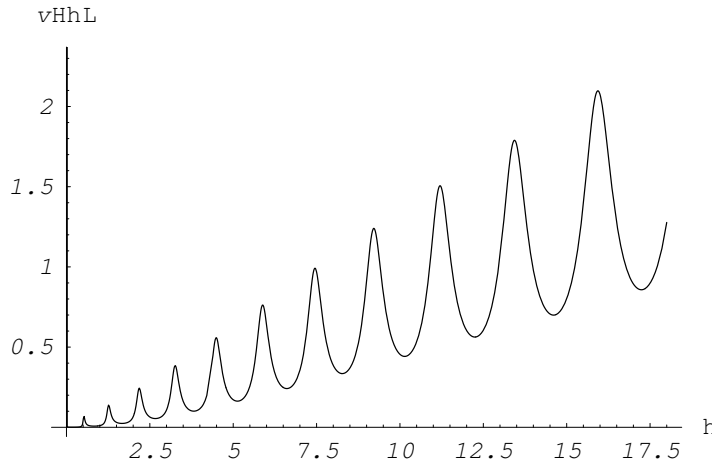


Figure 2: Temporal course of the radial velocity of the surface for the whole time scale from the big start to  $18 \cdot 10^9$  y

From formula (2) we learn that the scalaric cosmic expansion factor  $E_S$  contains  $M_c$  quadratically. That means under the circumstances of the exponential character of the expansion law (4) an extraordinary sensitivity of the radius on the mass  $M_c$ .

With the aim of illustration we also performed the calculations on the basis of the total mass of the Galaxy  $M_{c/total} = 2 \cdot 10^{45}$  g (to be found in astrophysical literature), arriving at the rescaled temporal curves for the radius  $R(\eta)$  and the radial expansion velocity  $V(\eta)$ , both presented in Fig. 3 and Fig. 4. Hence the present value of the radial expansion velocity  $V_p = 55$  cm/y results.

The following figures show the temporal course of  $R(\eta)$  and  $V(\eta)$ .

Let us conclude this paper with the general remark that in Fig. 1 and Fig. 2 the curves show a quasi-continuous course through the whole time scale from the big start to the presence, i.e. there is no hint at the time of birth of the cosmic object considered. In contrast to this behavior in Fig. 3 and Fig. 4 the birth is significantly marked by a steep rise. All in all it seems that this theory corresponds to a longtime evolution of the star-like cosmic objects from “small to large” and not according to the accretion concept from “large to small”.

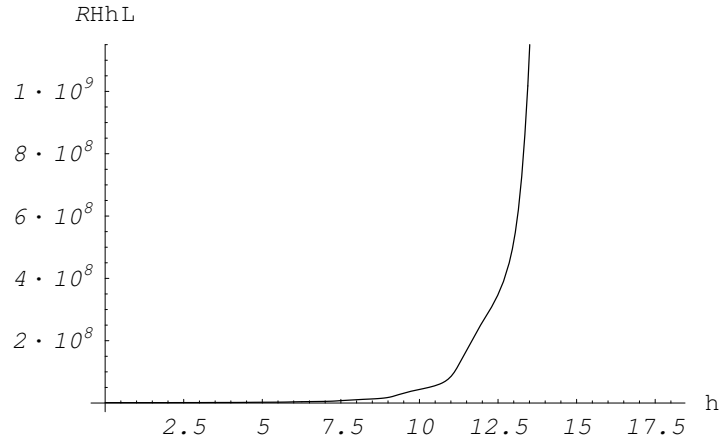


Figure 3: Temporal course of the radius for the whole time scale from the big start to  $18 \cdot 10^9$  y (different numerical variant)

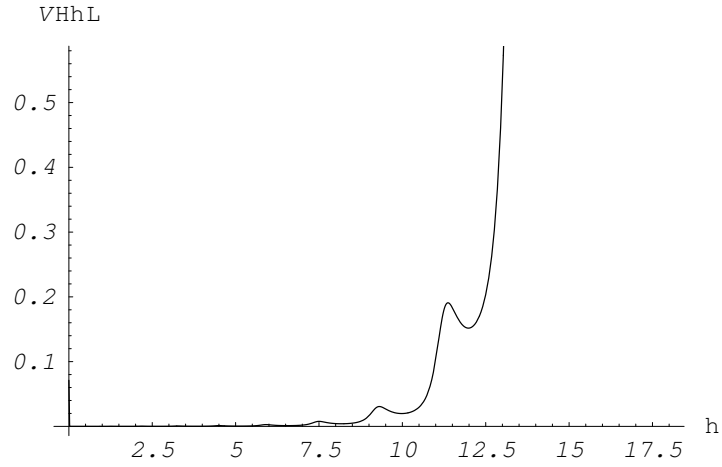


Figure 4: Temporal course of the radial velocity of the surface for the whole time scale from the big start to  $18 \cdot 10^9$  y (different numerical variant)

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### References

- Korycansky, D. G. , G. Laughlin and Adams, F. C.: 2001, arXiv:astro-ph/0102126 (7 Feb), Astrophysics and Space Science (in press)
- Schmutzer, E.: 1995, Fortschritte der Physik 43, 613
- Schmutzer, E.: 2000a, Astron. Nachr. 321, 227
- Schmutzer, E.: 2000b, Astron. Nachr. 321, 209
- Schmutzer, E.: 2001, Astron. Nachr. 93, 103

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